Research Article

Wireless Network Service Quality Analysis at Kefamenanu 1 State Vocational School using QoS Methods

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Abstract: Indonesia is one of the largest archipelagic countries in the world, one of the challenges is that the existing internet network is not optimal and should be evenly distributed throughout Indonesia. This article is one of the efforts to increase the capacity and use of the internet, especially to support the education process which should be evenly distributed in various regions in Indonesia, not only in Java but also in areas outside Java. especially in East Nusa Tenggara. NTT is one of the areas discussed in this article, specifically at Kefamenanu 1 State Vocational School. This article puts forward some essential aspects in the development and installation of the internet in this school, including using the right measurements of Quality of Service (QoS). QoS includes many things such as Throughput, Bandwidth, Packet Loss, and other parameters that are essential in building and analyzing internet networks that have a wide scope, especially for the Education level. Vocational High Schools are not only expected to be able to use the internet but also build, design, install, and perform detailed analysis on the internet network they build. Two essential networks must be able to be installed, i.e., a Wireless Network and Local Area Network.

Keywords: Quality of Service, Internet Network, Education, Wireless Network, ISP

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1. Introduction

The Internet has been used by all sectors ranging from education, business, entertainment, government, and religion. With this internet technology, it makes human work more effective and efficient. So it can be said that the internet has brought great changes to human life. The increasing number of internet users requires internet services with adequate quality to meet the internet needs of all users. In Indonesia, the company that provides internet services is generally Telkom. Telkom will distribute internet connections to its customers to make it easier for internet users. Network services provided by ISPs must meet specified standards which are usually called Quality of Service (QoS) (Mukti, F.S. et.al.,2021). QoS is the ability of a network to provide better service for users. By analyzing the Quality of Service (QoS) of the existing internet network, it will produce information in the form of internet network analysis results that follow the Quality of Services (QoS) standard (P.D.P.Adi and Akio Kitagawa,2019), namely THIPON (Telecommunications and Internet Protocol Harmonization Over Network) ETSI TR 101 329 V2.1.1 (1999-06) issued by ETSI (European Telecommunications Standards Institute) Quality of Service value. The results of the analysis can be used as a benchmark and can be taken into consideration by network administrators to improve the quality of existing network services. Furthermore, Kefamenanu 1 State Vocational School is one of the vocational high schools in TTU which is located on Eltari Street Km 9 village Sasi sub-district Kefamenanu City. Kefamenanu 1 State Vocational School has the status of government ownership which was established on October 23, 1999, and is one of the reference schools.

Furthermore, The learning model used is a dual model, where students will practice at school and in the business world for approximately 6 months to explore the knowledge that has been learned at school according to their respective expertise programs. Kefamenanu 1 State Vocational School provides internet services as one of the infrastructures for smooth learning at school. This school also has 8 expertise programs, and each expertise program has its internet network. The type of topology used is infrastructure topology.

Moreover, at this time Kefamenanu 1 State Vocational School has never carried out the process of analyzing the quality of network services so there are no benchmarks that can be used to improve the quality of existing network services. To improve the network for each skill program, an analysis is needed to determine whether the network provided meets the standards or not, and whether all rumble in the Computer & Network Engineering (TKJ) skill program receive the same quality of network service or not. The analysis of the quality of network services carried out only involves one expertise program, namely the TKJ program. The selection of the TKJ program is based on the consideration of research sampling with a purposive sampling technique. A good network service is a network that can handle all user needs and must meet Thipon standards. Here the author will analyze the quality of network services of Kefamenanu 1 State Vocational School in the TKJ expertise program. The author will use every class in the TKJ expertise program as a class.

2. Theory

2.1 Internet network analysis

Analysis is the process of breaking down a subject into its various parts and examining the parts themselves and the relationship between several parts to obtain a correct understanding and understanding of the meaning of the whole. So it can be said that analysis is the inference of large amounts of raw data so that the results can be interpreted (Yuli Siyamto, 2019). "Interconnection-networking (Internet) is a global system of computer networks that connect each other throughout the world" (Dewantara et al., 2022). So it can be concluded that analyzing the quality of internet network services is the decomposition of an existing internet network which is divided into several components including data transfer speed, the number of data packets received must be the same as the number of data packets sent, and the time required in data transmission to obtain information on whether the network has good quality or not.

2.2 Wireless Network

A wireless network is a network that does not use cables as a data transmission medium. Wireless networks are networks that use radio and infrared waves as a medium for transmission and communication to a set of devices in the vicinity. Examples of wireless networks are Bluetooth, wifi, radio networks, and cellular technology such as 4G and 5G networks, and 6G in current development. Accordingly, Types of Wireless Networks are divided into several. There are various types of wireless networks that we often encounter in our daily lives. However, when viewed based on their range, wireless networks are generally divided into four, Sutiono M.Kom., 2023): The first type discussed is the *Wireless Personal Area Network (WPAN)*. WPAN is a wireless personal area network or personal network technology such as Bluetooth (IEEE 802.15) (P.D.P.Adi and Akio Kitagawa, 2018) and Infrared (IR), which requires a direct connection and a relatively small range. WPAN requires low power and its coverage area is also very narrow. In this type of network, the connection between personal equipment in an area is around 30 feet (1 foot = 12 inches) or 9 meters.

Furthermore, The next type of Wireless Network is a *Wireless Local Area Network (WLAN).* WLAN has a wider area coverage than WPAN, such as in the area of buildings, offices, laboratories, and so on. WLAN allows two devices to be connected to exchange data or information. WLAN provides connections

through access points for a wider internet network. The data transfer speed can reach 54 MBps and the coverage area is 45 m. One of the things included in WLAN is a Wi-Fi (Wireless Fidelity) network. The model on the WLAN network is divided into two, i.e., the Ad-Hoc Model and the Infrastructure Model. The Ad-Hoc model is classified as an uncomplicated network because hosts do not need an access point to communicate with each other. Hosts only need a wireless transmitter and receiver to communicate. An infrastructure model that uses access points to communicate. Access points as the main role in a network. Configuring and adding to this access point will increase the coverage of the existing wireless network.

Moreover, the type of Wireless Network specifically used in Metropolitan is called *Wireless Metropolitan Area Network (WMAN)*. Wireless Metropolitan Area Network (WMAN) is a general term for networks that are limited to a geographic area as well as some specialized network technologies that provide wireless communications in metropolitan areas. WMAN networks provide network access to data, audio, video, and multimedia services to a metropolitan or regional coverage area, both urban and rural with a radius of 50 km with large data transfer rates of up to 70 MBps. Although WMAN provides citywide coverage, in reality, the coverage area may be as small as a university campus or even a few buildings. A network operator's or ISP's WMAN is, in many cases, an extension of the wireless service provided by a wired or wireless operator.

Meanwhile, a *Wireless Wide Area Network (WWAN)* is a wireless network that makes it possible for users to connect through public and private networks with a very large coverage area without any space and time restrictions. Besides using a satellite system, ISP WWAN will usually place several antennas in certain areas to support network connectivity. The use of WWAN technology that has been implemented to date is the 4G network and in the future, it will enter the era of the latest generation, the 5G network, and also 6G in development.

2.3 *Quality of Service*

QoS (Quality of Service), according to CCITT E.800 is a service performance used to determine the degree of satisfaction of a user with a service. QoS is the ability of a network to provide better service for traffic services that pass through it (Alwi & Ilmawan, 2019). With QoS, a network administrator will be able to prioritize certain data traffic. The purpose of QoS is to provide adequate quality of service to answer user needs and create comfort for users.

QoS parameters include Bandwidth. Bandwidth is the amount of data that can be transmitted from one place to another within a certain period. Bandwidth is a very important measure in networking, but this concept has shortcomings or limitations due to the laws of physics and technological limitations that provide limits on the length, maximum speed, or special treatment of the media that can be used (Sumbaryadi & Dwi Prasetyo, 2019). The standard used to measure Bandwidth is the standard issued by the FCC (Federal Communications Commission) that for students the recommended Bandwidth for download is 5-25 Mbps (FCC, 2022). The FCC only issues standards for downloads but for uploads, it is not issued because a student has the most download activities because it is used for browsing rather than uploading data.

The next essential parameter is Throughput. Throughput is the actual ability of a network to transmit data (Pusvita & Huda, 2019). Throughput in other words is the speed of effective data transmission and is measured in units of bps. Throughput in other words the total number of successful packets sent during a certain period divided by the duration of the transmission period.
Several factors can affect bandwidth and throughput, namely network devices, type of data transferred, number of users, type of network topology, client/user

specifications, computer server specifications, electricity induction, weather, and so on. Throughput is formulated as follows equation 1.

$$\text{Throughput}=(\text{ Package received (kb)}) / (\text{delivery time (s)}) \quad (1)$$

Furthermore, if associated with the number of bytes and period, Throughput is the amount of data per unit of time sent from a station to another station on a network. The following is the throughput calculation formula based on the data generated in the wireshark software. Throughput is formulated as equation 2.

$$\text{Throughput}=\text{bytes}/(\text{time span}) \quad (2)$$

The calculation results are multiplied by 8 for conversion from bytes to bits and then divided by 1000 for conversion from bits to kilobits per second (kbps) because the standard used is Kbps. The greater the Throughput, the better the network quality.

Moreover, Packet loss is defined as the number of data packets that fail when they arrive at the destination of the data packet. For the calculation of Packet loss parameters using Python. The smaller the packet loss, the better the network quality. Packet loss is formulated in Equation 3.

$$\text{Packet loss}=((\text{ Packages sent - packages received}))/(\text{ Sent package}) \times 100\% \quad (3)$$

Table 1. Throughput Category

Throughput Category	Throughput	Index
Very Bad	0-338 kbps	0
Bad	338-700 kbps	1
Medium	700-1200 kbps	2
Good	1200-2.1 Mbps	3
Very Good	>2.1 Mbps	4

2.4 Applications and Software used

One of the reliable software for Network traffic measurement is Wireshark. Wireshark is an open-source packet capture application that assists in scanning and capturing Internet service traffic. It is often used as a troubleshooting tool for problematic networks, using QoS parameters. This application was previously known as Ethereal, but due to trademark issues, the name was changed to Wireshark (Kamil et al., 2023). Wireshark is used to analyze networks. It works by capturing data packets from different protocols of various network types commonly found in internet network traffic. Then the capture results are displayed on a worksheet in real time.

The programming language used in this research is Python. Python is a high-level programming language created by Guido Van Rossum and released in 1991. Python is also a very popular language these days. In addition, Python is also a multi-functional programming language, one of which is in the field of Machine Learning and Deep Learning (Alfarizi et al., 2023). Moreover, Google Colab is an idea for Python programming where processing will be done by Google servers that have high-performance hardware (Gelar Guntara, 2023). Google Collab will

be used to process data from network testing results at Kefamenanu 1 State Vocational School obtained from wireshark software.

3. Method

3.1 Research Type

In this study, the authors used the Action Research type of research. The Action Research method is action research that focuses on the activities of researchers to find the problem under study (Kamil et al., 2023). This research method is commonly used for the process of testing developing, and creating a new action so that it can be applied. This type of research needs to look at one of the essential and fundamental methods, the Cycle of Action Research method, as shown in Figure 1.

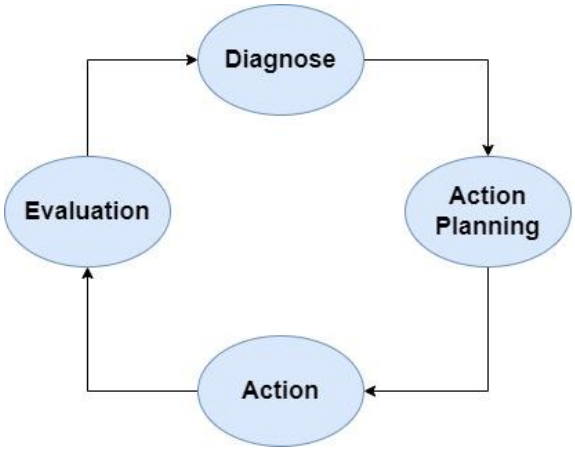

Figure 1. Cycle of Action Research method

Moreover, the analysis step is essential to do. In this analysis process, the author applies the QoS method in the process of analyzing data using 5 parameters, i.e., Bandwidth, Packet Loss, Delay, Jitter, and Throughput. These parameters will be detailed in the results shown in Chapter 4.

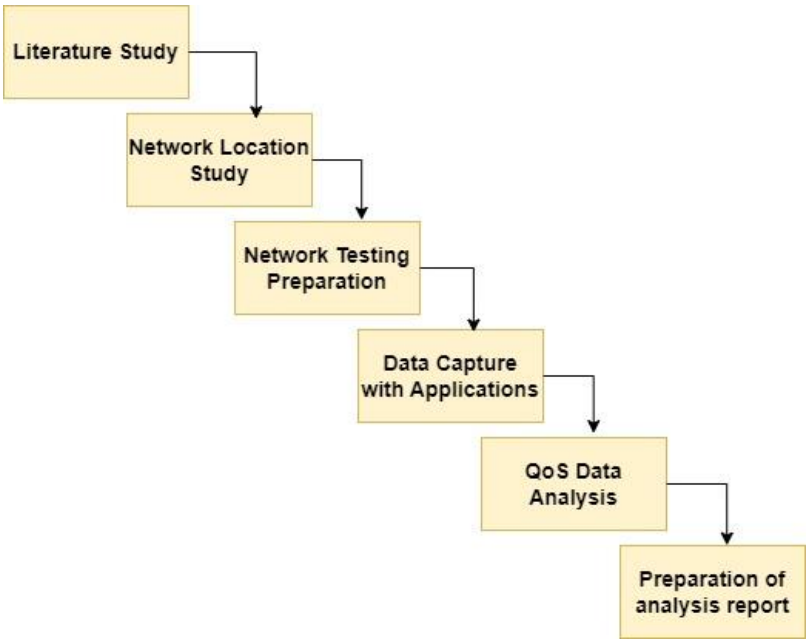

Figure 2. Research stages

Accordingly, Figure 2, is the Research Stages which is an essential stage in showing the results of this research analysis. This stage is one of the methods for completing this research. So that this research can be completed in an organized manner according to the existing stages. The research stages include a Literature Study, Network Location Study, Network Testing Preparation, Data Capture with Applications, QoS Data Analysis, and with preparation of an analysis report. This waterfall method can be seen in detail in Figure 2.

3.2 Sampling Technique

In this study, the authors will use a research sample whose samples are taken from the population of wireless networks in Kefamenanu 1 State Vocational School. In determining this sample, the authors used purposive sampling techniques. Purposive sampling is a non-random sampling method where the researcher ensures the quotation of illustrations through the method of determining special identities that match the research objectives so that they are expected to respond to the research case (Lenaini et al., 2021). In other words, the purposive sampling technique is a sampling technique based on the consideration of the researcher. Several things are taken into consideration by researchers when determining samples, namely: the number of users and the distance between the access point and the classroom. Based on the above considerations, the author will use the TKJ department as a research sample, because the highest number of users is 186 users and the distance between the access point and the classroom is far apart and blocked by trees.

3.3 Network Topology

The detailed Network Topology is shown in Figure 3.

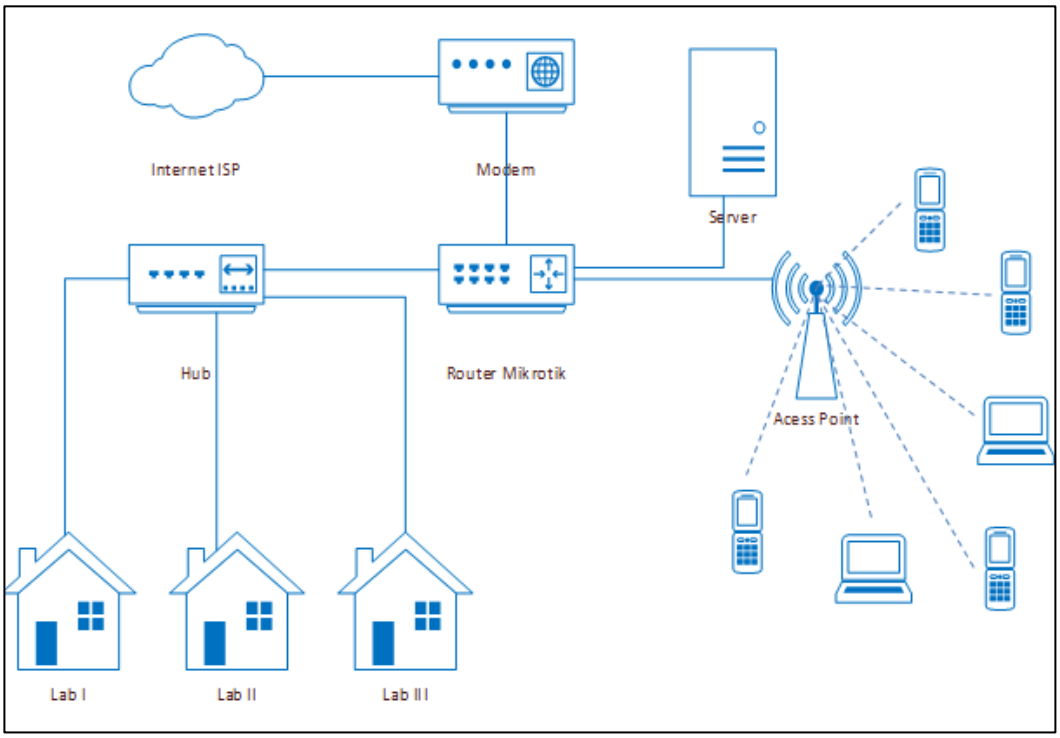

Figure 3. Network Topology

In the network testing process, the software used is Wireshark. Before wireshark is used this application must be configured first to select the network type, protocol, source IP address, destination IP address, data size, and time required when transferring data to be used to capture data traffic passing through the network.

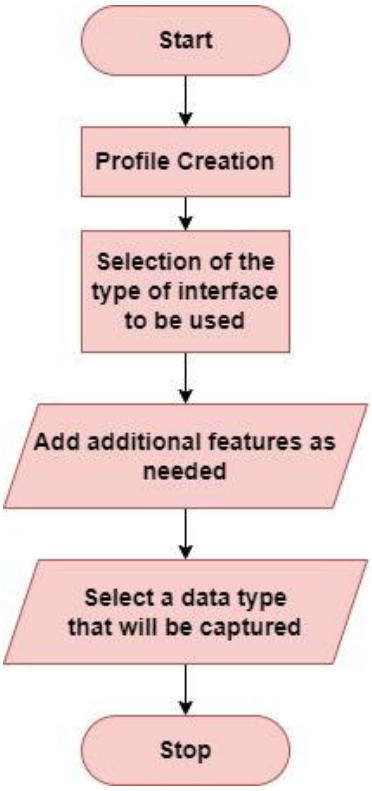

Figure 4. Wireshark configuration process

In this configuration process, the first thing to do is to create a profile. After creating a profile, the next step is to select the type of interface that will be used for the data-capturing process. The next process is to add the required features such as time, IP port, data size, and network protocol. After that, the selection of data capturing type can be done based on data size, observation time, or protocol used.

The next step is to test the wireless network in the TKJ expertise program using Wireshark and Google speed tests. This school uses a dual learning method, namely theoretical and practical learning. The testing process is carried out for two days when the user is busy and when it is quiet. The first day is a day that is busy with the learning process, while the second day is a day when learning activities are not so dense and filled with practice in their respective workshops. The purpose of testing on two different days is to see the comparison between internet network quality based on varying user traffic density.

The test results will be stored in CSV form and then will be calculated using manual calculations on Ms. Excel and will be implemented in Python. The test results will be analyzed using Python Jupiter through Google Collab.

4. Result and Analysis

This research was conducted at Kefamenanu 1 State Vocational School. The school is a vocational high school that has eight (8) expertise programs. Where each expertise program has its wireless network, and the school administration also uses one wireless network. Therefore, this school uses 9 wireless networks with an access speed of 100 Mbps and a network frequency of 2.4 GHz using an infrastructure topology.

The problem that researchers found during the observation was that the internet network at Kefamenanu 1 State Vocational School had never been analyzed for quality and the distance between the access point and the class, where each rumble had a long distance. So several classes are not reached by the internet network so students have difficulty accessing the internet.

Figure 5. Access Point Distribution Plan at Kefamenanu 1 State Vocational School

Furthermore, this planning process is divided into two parts, namely determining the location and configuration of the Wireshark application to be used later to capture data packets that cross network traffic. The next step is the Determination of class location. Based on the sampling technique that has been carried out, namely the purposive sampling technique, the network testing process will be carried out in the TKJ expertise program. The testing process is carried out in five (5) classes in this expertise program, namely classes 10 TKJ, 11 TKJ 1, 11 TKJ 2, 12 TKJ 1 and 12 TKJ 2. Figure 5 shows the Access Point Distribution Plan at Kefamenanu 1 State Vocational School, while Figure 6 shows the Access Point whose position is in the TKJ Workshop.

Figure 6. Access point whose position is in the TKJ Workshop

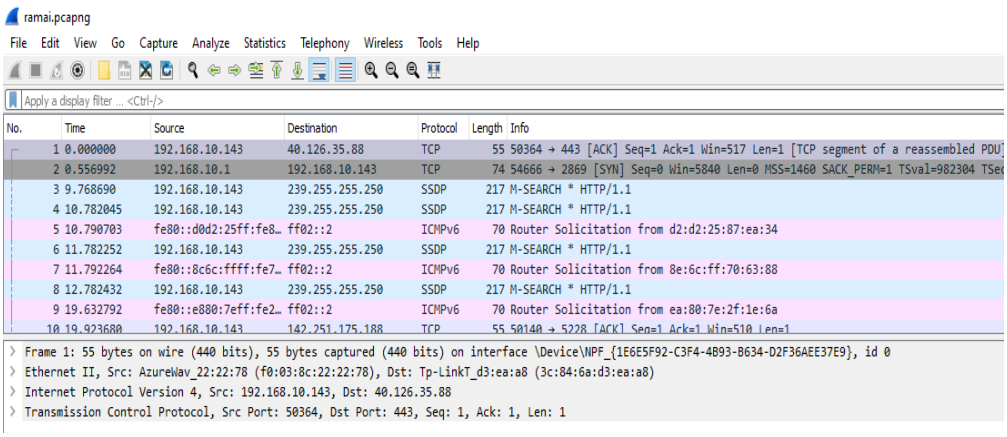

Figure 7. Wireless network testing process with Wireshark

Furthermore, at this evaluation stage, the author will calculate data based on parameters. There are 5 parameters used, i.e., Bandwidth, Packet loss, Throughput, Delay, and Jitter. Calculation of these five parameters using Python with Google Collab. Bandwidth is a measure of the amount of information that can flow from one place to another in a certain time. Bandwidth measurement using Google Speed Test. The greater the bandwidth, the better the network quality.

```
df['BANDWIDTH']
bandwidth = df.loc[0, 'BANDWIDTH']
print(bandwidth)
```

```
4.8
```

```
#Berdasarkan standar FCC rekomendasi bandiwidth untuk pelajar adalah 5-25 Mbps
if bandwidth <5:
    print("Kondisi jaringan berdasarkan parameter bandwidth belum memenuhi standar")
else:
    print("Kondisi jaringan berdasarkan parameter bandwidth sudah memenuhi standar")
```

```
Kondisi jaringan berdasarkan parameter bandwidth belum memenuhi standar
```

Figure 8. Bandwidth analysis with Google Colab

```
df['PACKET DIKIRIM']
Packet_dikirim = df.loc[0, 'PACKET DIKIRIM']
print(('Jumlah Paket yang dikirim adalah'),(Packet_dikirim))
```

```
Jumlah Paket yang dikirim adalah 95.0
```

```
df['PACKET DITERIMA']
Packet_diterima = df.loc[0, 'PACKET DITERIMA']
print(('Jumlah Paket yang diterima adalah'),(Packet_diterima))
```

```
Jumlah Paket yang diterima adalah 95.0
```

```
#perhitungan parameter packet loss
Packet_loss=(((Packet_dikirim)-(Packet_diterima))/(Packet_dikirim))*100
print(('Presentasi paket loss adalah'),(Packet_loss),('%'))
```

```
Presentasi paket loss adalah 0.0 %
```

```
#analisis berdasarkan parameter QoS
if Packet_loss > 25 :
    print("Kondisi jaringan berdasarkan parameter Packes_Loss adalah  buruk")
elif (Packet_loss <24) & (Packet_loss >12):
    print("Kondisi jaringan berdasarkan parameter Packes_Loss adalah sedang")
elif (Packet_loss <14) & (Packet_loss > 3):
    print("Kondisi jaringan berdasarkan parameter Packes_Loss adalah  baik")
else:
    print("Kondisi jaringan berdasarkan parameter Packes_Loss adalah sangat baik")
```

Figure 9. Packet loss analysis with Google Colab

```
[ ] #Rumus perhitungan troughpu = Jumlah bytes : Time Span
    #Menampilkan Time spn
    df['JUMLAH BYTES']
    jumlah_bytes = df.loc[0, 'JUMLAH BYTES']
    print(jumlah_bytes)

    3592106.0

[ ] #menampilkan Time span
    df['TIME SPAN']
    time_span = df.loc[0, 'TIME SPAN']
    print(time_span)

    59.324

[ ] #Menhitung trouhgput
    troghput= (jumlah_bytes) / (time_span) * 8 / 1000
    print(('Hasil Trouhgputnya adalah'),(troghput), ('Kbbp'))

    Hasil Trouhgputnya adalah 484.4050974310566 Kbbp

    #analisis berdasarkan parameter QoS
    if (troghput <338) &  (troghput >=0):
        print("Kondisi jaringan berdasarkan parameter throughput adalah sangat buruk")
    elif (troghput <700) & (troghput > 338):
        print("Kondisi jaringan berdasarkan parameter throughput adalah buruk")
    elif (troghput <1200) & (troghput >700):
        print("Kondisi jaringan berdasarkan parameter throughput adalah sedang")
    elif (troghput <2100) & (troghput > 1200):
        print("Kondisi jaringan berdasarkan parameter throughput adalah  baik")
    else:
        print("Kondisi jaringan berdasarkan parameter throughput adalah sangat baik")
```

Figure 10. Throughput analysis with Google Colab

```
    df['Hasil'] = df['TIME 2'] - df['TIME 1']
    print(df['Hasil'])

    0       0.271597
    1       0.000000
    2       0.000000
    3       0.000979
    4       0.000000
              ...
    4226    0.000000
    4227    0.000000
    4228    0.000000
    4229    0.000219
    4230         NaN
    Name: Hasil, Length: 4231, dtype: float64

[ ] mean_delay = df['Hasil'].mean()
    print("Rata-rata Delay:", mean_delay)

    Rata-rata Delay: 0.19285374468085106

[ ] #karena delay ini Data yang dihasilkan data sekon untuk sedangkan standar yang
    #digunakan adalah milisecon maka data harus dikali dengan 1000.
    delay = mean_delay * 1000
    print('Hasil delaynya adalah', delay)

    Hasil delaynya adalah 192.85374468085107

[ ] #analisis berdasarkan parameter QoS
    if delay > 450 :
        print("Kondisi jaringan berdasarkan parameter delay adalah  buruk")
    elif (delay <450) & (delay >300):
        print("Kondisi jaringan berdasarkan parameter delay adalah sedang")
    elif (delay <300) & (delay > 150):
        print("Kondisi jaringan berdasarkan parameter delay adalah  baik")
    else:
        print("Kondisi jaringan berdasarkan parameter delay adalah sangat baik")
```

Figure 11. Delay analysis with Google Colab

Jitter is the variation or change in latency from delay or variation in packet arrival time. Jitter results are obtained from delay variations. The calculation results will be multiplied by 1000 for conversion from seconds to milliseconds because the standard used is milliseconds. The smaller the jitter, the better the network quality.

```
[ ] #Menghitung delay 1
    df_differences= [j - i for i, j in zip (df['Hasil'][:-1], df['Hasil'][1:])]
    df_delay1= [-1 * x for x in (df_differences)  ]
    df['1'] = pd.DataFrame(df_delay1)
    print(df['1'])

    Tampilkan output tersembunyi

[ ] #Menghitug delay 2
    delay2= df.drop(index=0).reset_index(drop=True)

    df['delay_2'] = delay2['Hasil']
    print(df['delay_2'])

    Tampilkan output tersembunyi

[ ] #Perhitunga jitter
    df['jitter'] = (df['delay_2']) - df['1']
    print (df['jitter'])

    Tampilkan output tersembunyi

[ ] mean_jitter = df['jitter'].mean()
    print("Rata-rata Jitter:", mean_jitter)

    Rata-rata Jitter: 0.013899580042563255

[ ] #Data yang dihasilkan data sekon untuk sedangkan standar yang digunakan adalah milisecon maka data harus dikali dengan 1000.
    jitter=mean_jitter * 1000
    print(jitter)
```

Figure 12. Jitter calculation

The calculation results will be adjusted to the standards set by Thipon and FCC. Then the test data will be grouped based on the network test time to visualize the data per class. The resulting data will be used as a study material for improving the quality of existing network services.

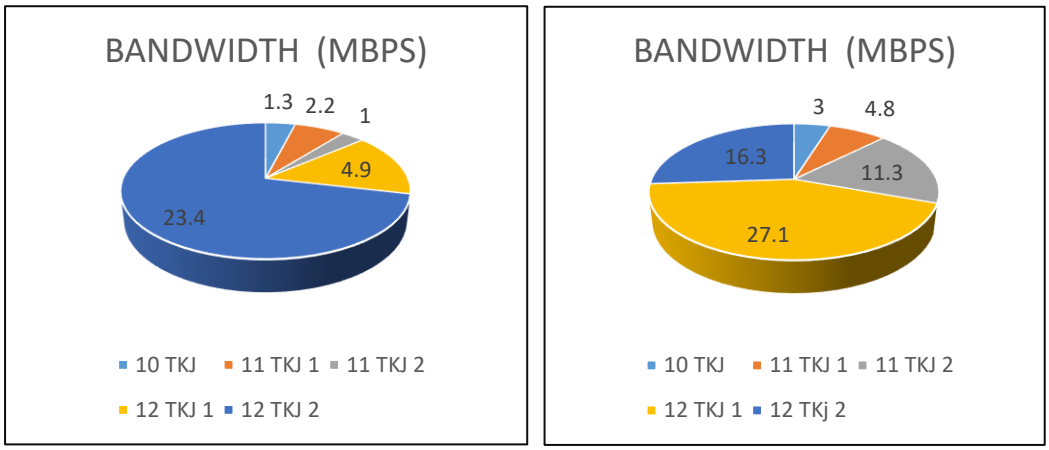

Figure 13. Day 1: (a) Bandwidth on the day first day when it's crowded, (b) Bandwidth on the first day when it is quiet

Network testing was carried out on two days under different circumstances, namely quiet and busy times. The measurement results include the following, [1] First Day. The network testing process was carried out on the first day when the school was busy and quiet the results are shown in the two diagrams in Figure 13 a and b.

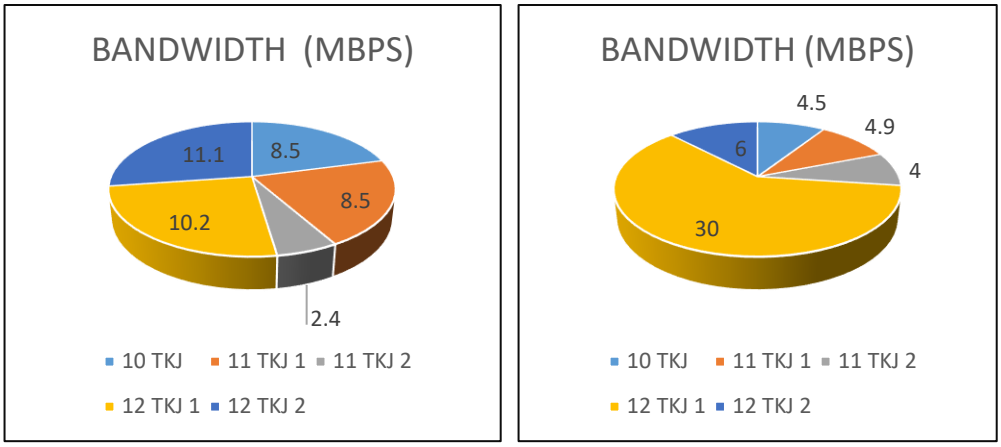

Figure 14. Day 2: (a) Bandwidth on the day first day when it's crowded, (b) Bandwidth on the first day when it is quiet

The results of bandwidth parameter analysis on the first day when the school is busy are shown in Figure 14. From this figure it can be seen that class 10 TKJ gets 8.5 Mbps bandwidth, class 11 TKJ 1 gets 8.5 Mbps, class 11 TKJ 2 gets 2.4 Mbps, class 12 TKJ 1 gets 10.2 Mbps, and class 12 TKJ 2 gets 11.1 Mbps. The results of bandwidth analysis based on the standards set by the FCC show that class 11 TKJ 2 has a bandwidth that does not meet the standards so there needs to be an effort to increase bandwidth in this class. Furthermore, pada Parameter Throughput, The following are the results of network testing carried out on the first day of school when it was busy and quiet as shown in the two graphs in Figure 15.

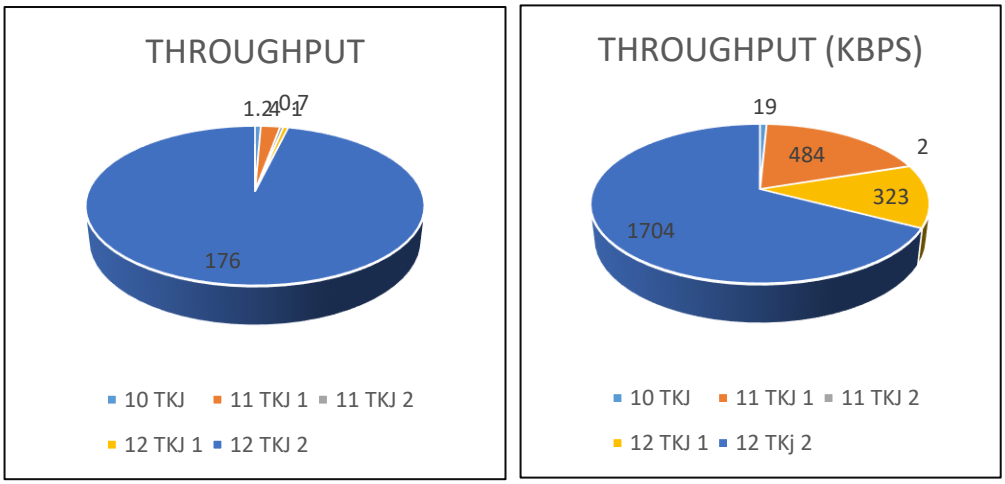

Figure 15. Day 1. (a) Throughput presentation on the first day when it was crowded, (b) Throughput presentation on the first day when it was quiet

It can be seen from Figure 15 that on the first day when the school is crowded, class 10 TKJ gets a throughput of 1.2 kbps, class 11 TKJ 1 gets 4.0 kbps, class 11 TKJ 2 gets 0.7 kbps, class 12 TKJ 1 gets 1.0 kbps, and class 12 TKJ 2 gets 9 kbps. The results of the analysis based on the Thipon standard show that the data transfer speed of these five classes is still very poor which causes the network to be very slow so efforts need to be made to improve these classes.

Network conditions on the first day of testing when it is quiet can be seen in Figure 4.15. Based on this figure, class 10 TKJ gets a throughput of 19 kbps, class 11 TKJ 1 gets 484 kbps, class 11 TKJ 2 gets 2 kbps, class 12 TKJ 1 gets 323 kbps, and class 12 TKJ 2 gets 1704 kbps. Based on the analysis results compared to the Thipon standard, it shows that class

10 TKJ, 11 TKJ 2, and class 12 TKJ 1 are in very poor condition. Class 11 TKJ 1 is in poor condition and 12 TKJ 2 is in good condition.

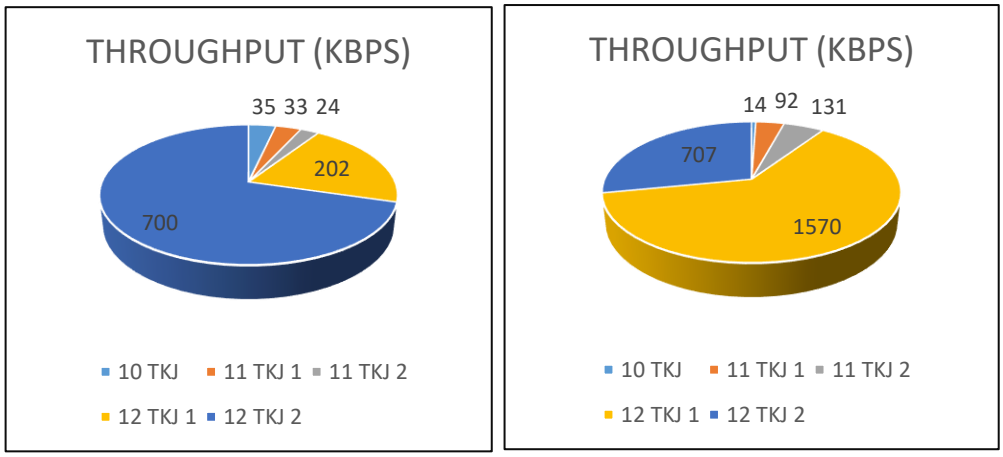

Figure 16. Day 2. (a) Throughput presentation on the first day when it was crowded, (b) Throughput presentation on the first day when it was quiet

The throughput results on the second day when crowded are shown in Figure 15. Based on this figure, class 10 TKJ gets a throughput of 35 kbps, class 11 TKJ 1 gets 33 kbps, class 11 TKJ 2 gets 24 kbps, class 12 TKJ 1 gets 202 kbps, and class 12 TKJ 2 gets 700 kbps. The test results for the throughput parameters of these five classes show that the data transfer speed of these five classes is very poor which causes the network to be very slow so there needs to be an effort to improve these classes. And only one class is in good condition, namely class 12 TKJ 2.

Figure 16 is the throughput result on the second day when it is quiet. From this figure, class 10 TKJ gets a throughput of 14 kbps, class 11 TKJ 1 gets 92 kbps, class 11 TKJ 2 gets 131 kbps, class 12 TKJ 1 gets 1570 kbps, and class 12 TKJ 2 gets 707 kbps. The results of the analysis show that class 10 TKJ, 11 TKJ 1 and class 11 TKJ 2 are in very poor condition so improvement efforts are needed, class 12 TKJ 1 is in good condition, and 12 TKJ 2 is in moderate condition so that the internet speed in this class meets the standards.

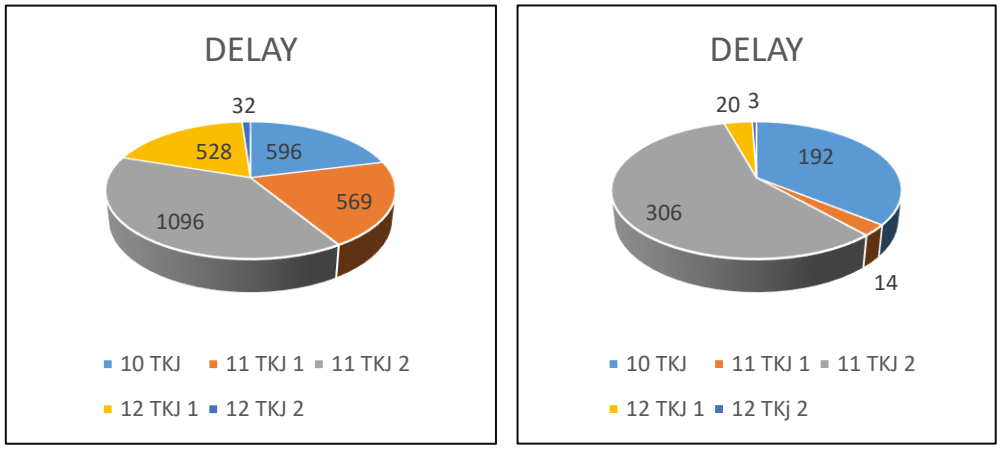

Figure 17. Day 1. (a) Delay presentation on the first day when it was crowded, (b) Delay presentation on the first day when it was quiet

Figure 17 shows that in the network testing process when the school is crowded, class 10 TKJ gets a delay of 589 ms, class 11 TKJ 1 gets 569 ms, class 11 TKJ 2 gets 1096 ms, class 12 TKJ 1 gets 528 ms, and class 12 TKJ 2 gets 105 ms. The results of the delay parameter analysis show that class 11 TKJ 2 is in very good condition, and classes 10 TKJ, 11 TKJ 1, 12 TKJ 1, and 12 TKJ 2 are in poor condition.

The results of delay analysis on the first day of testing when the school is quiet are shown in Figure 18. From this figure, it can be seen that when the school is quiet above the 10th-grade TKJ class gets a delay of 192 ms, 11th-grade TKJ 1 gets 14 ms, 11th-grade TKJ 2 gets 306 ms, 12th-grade TKJ 1 gets 20 ms, and 12th-grade TKJ 2 gets 3 ms. The test results show that all classes 11 TKJ 1, 12 TKJ 1, and 12 TKJ 2 are in very good condition. Meanwhile, class 10 TKJ is in good condition and class 11 TKJ 2 is in moderate condition so improvement efforts are needed.

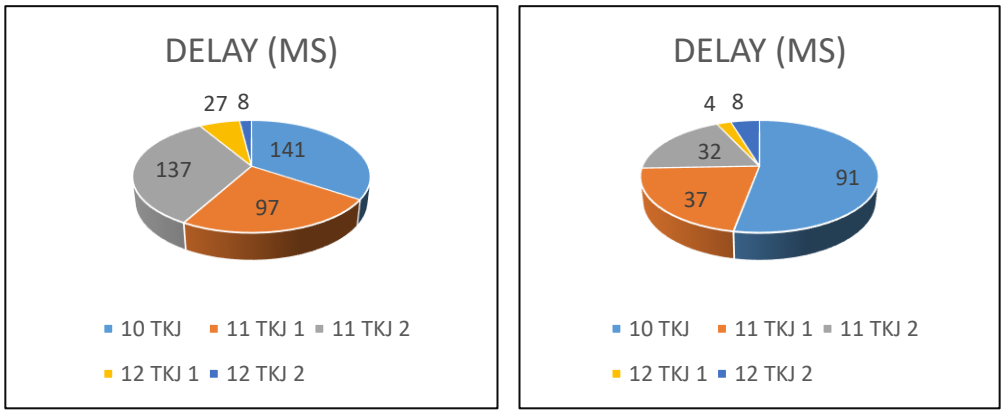

Figure 18. Day 2. (a) Delay presentation on the first day when it was crowded, (b) Delay presentation on the first day when it was quiet

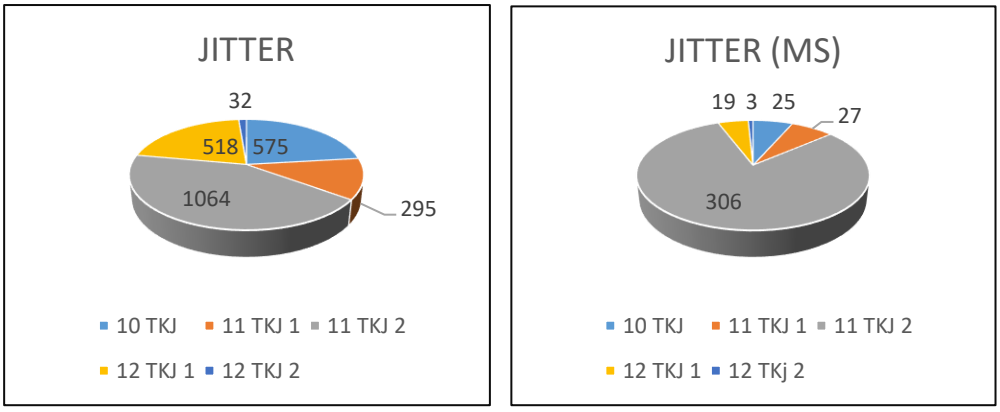

Figure 19. Day 1. (a) Jitter presentation on the first day when it was crowded, (b) Jitter presentation on the first day when it was quiet

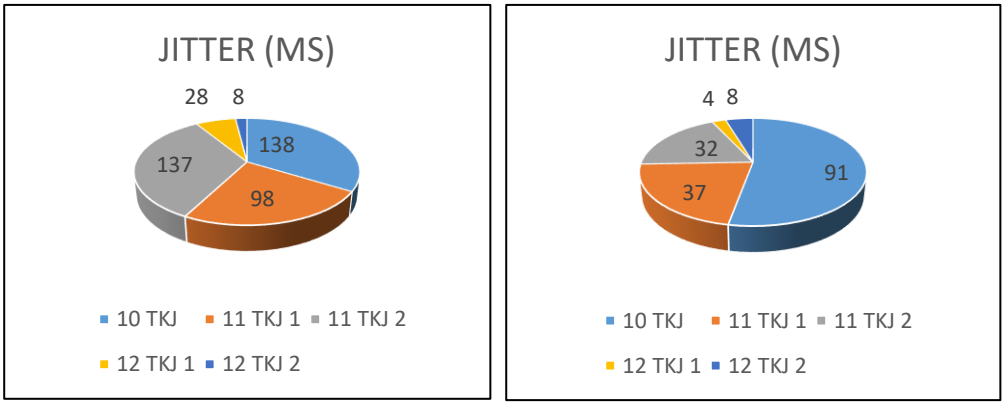

Figure 20. Day 2. (a) Jitter presentation on the first day when it was crowded, (b) Jitter presentation on the first day when it was quiet.

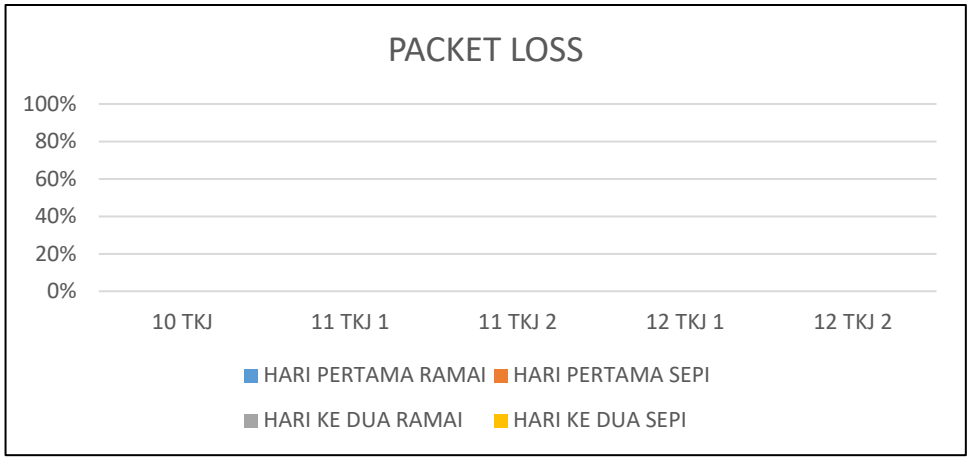

Figure 21. Packet loss comparison on all four tests

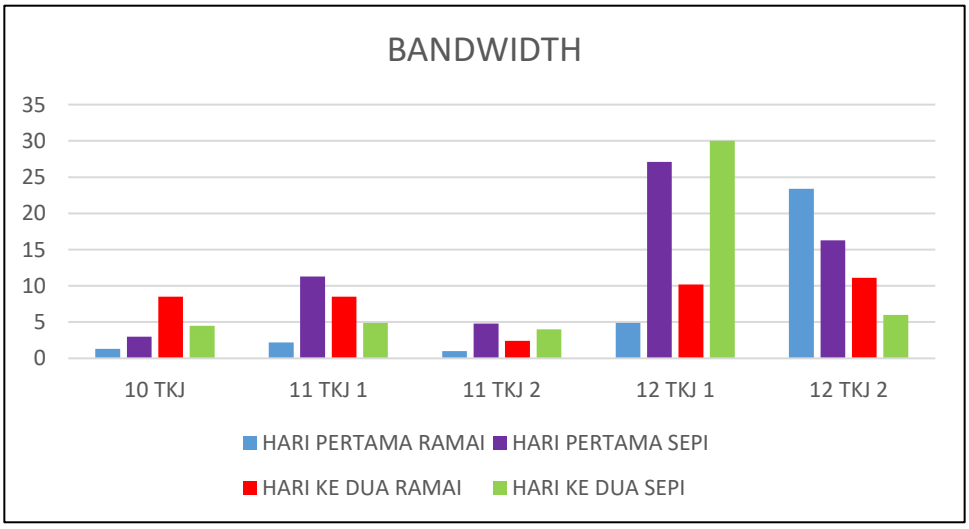

Figure 22. Bandwidth comparison on all four tests

The results of packet loss analysis Figure 21 in the four tests are visualized in the figure above, when testing on these five classes on two different days there were no packets lost, or in other words all packets were sent properly. Packet loss on the network usually occurs due to problems on the server or there is a damaged port cable. This shows that the network hardware is in good condition. In addition, the high packet loss is also caused by the use of firewalls. A firewall or firewall is a software system that allows network traffic that is considered safe to pass through and prevents network traffic that is considered unsafe (Gregorius Hendita, 2022). The school does not use a firewall so that all transmitted data packets can be sent properly and no packets experience failures in transmission.

Moreover, a Comparison of bandwidth in Figure 22 obtained by users during network testing is presented in the figure above. When testing the five classes, we can see that when the practice at school takes place the bandwidth size is getting bigger, this is because when carrying out the practice the students are asked to collect their phones automatically network users decrease. The fewer network users, the greater the bandwidth. The class that gets the lowest bandwidth is in class 10 TKJ, 11 TKJ 1, and 11 TKJ 2, this is due to the distance from the access point to the class which is far apart and blocked by a wall. This has also been described by (Hafazah et al., 2018) from the results of the tests conducted based on distance, the further the distance between access points, the bandwidth sent is divided and the throughput results are getting smaller. Based on the results of the analysis, it is found that the distribution of bandwidth for users is currently uneven. So it

is necessary to do bandwidth management so that all users get the same internet network quality.

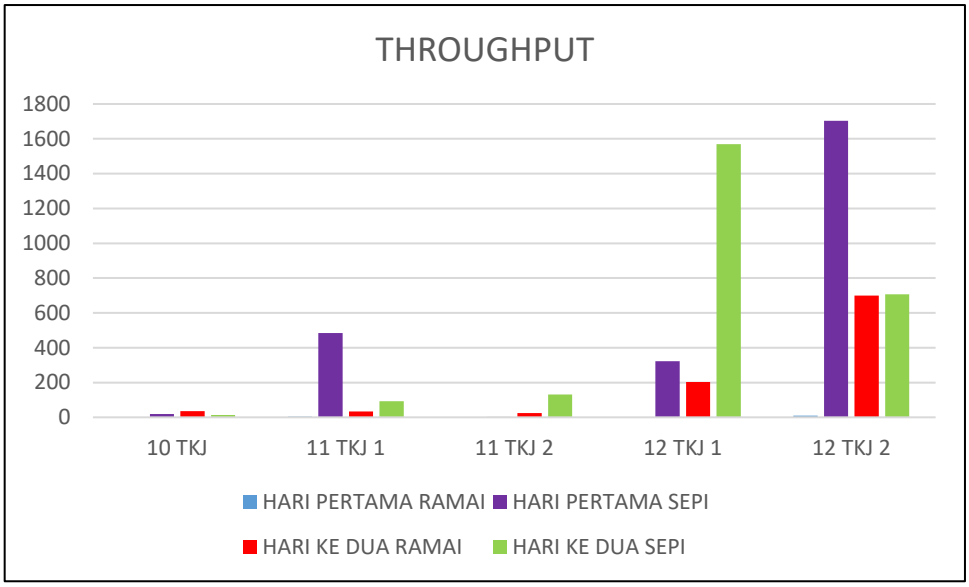

Figure 23. Comparison of throughput in the four tests

Figure 23 is a throughput comparison graph on the four network tests. The graph shows that the largest throughput parameter was during the second day of testing. When the second day of testing took place, class 12 TKJ was practicing in the workshop to prepare for the UKK (Expertise Potential exam), only a few classes were using the internet connection at that time. This throughput is very dependent on the bandwidth obtained, the greater the bandwidth obtained, the greater the data transfer speed (Rifki Wardana & Santoso, 2023). At the time of testing in these five classes, the classes that got the lowest throughput or speed were classes 10 TKJ, 11 TKJ 1, and 11 TKJ 2. One of the factors causing this is the distance of the access point to classes 11 TKJ 1 and 2 which are far apart, while the adjacent class 10 TKJ also has problems because it is blocked by solid objects (walls). The results of this test are in line with tests conducted by (Mahfuzhi et al., 2023) which also show that the amount throughout is also influenced by the distance of the access point and the place to access the internet.

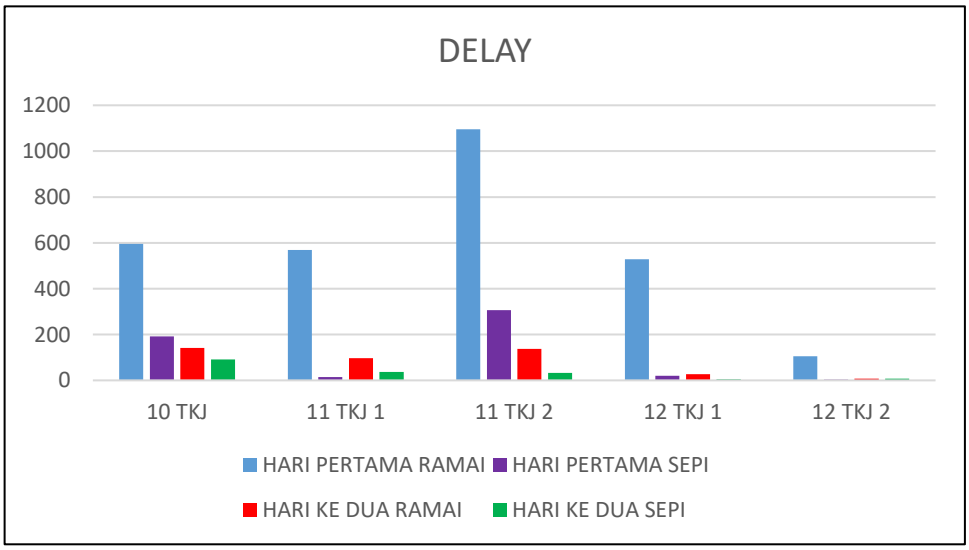

Figure 24. Comparison of delay in the four tests

Moreover, from Figure 24, it can be seen that the highest delay presentation occurred during the first day of testing when conditions were crowded. This is caused by very many network users so the bandwidth obtained by users is getting smaller. This condition slows down the data transfer process, and this slow data transfer process causes high delay. At the time of testing in these five classes, the class that got the highest delay was in class 11 TKJ 2, this was due to the long distance and very many users. Similar research has been conducted (Alwi & Ilmawan, 2019) and the results show that the highest delay conditions also occur when user conditions are crowded.

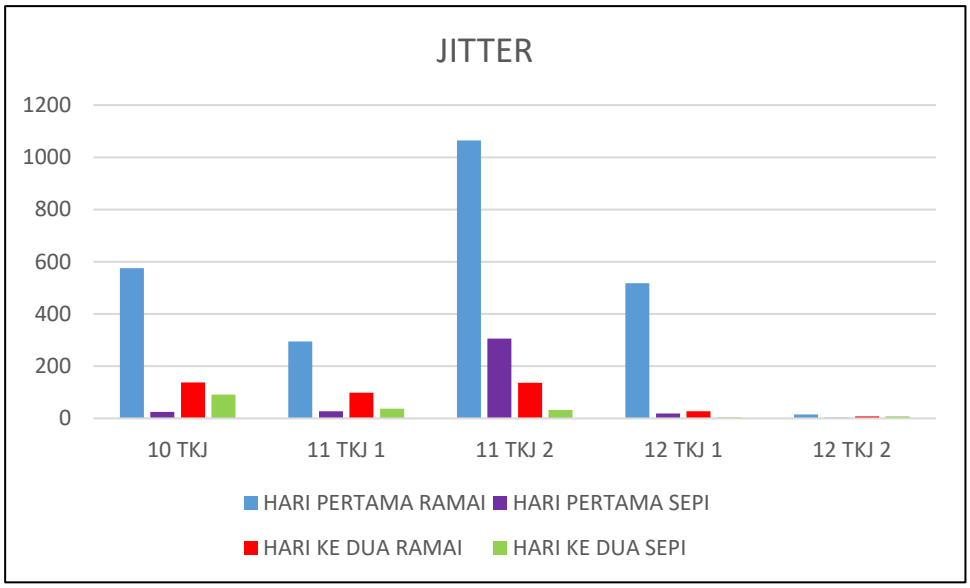

Figure 25. Jitter comparison on the four tests

A comparison of jitter in the four tests can be seen in the figure above. Figure 25 shows that bad jitter conditions occur during the first day of testing when the school is crowded. Jitter itself is a variation of delay, jitter presentation is very dependent on delay presentation, the higher the delay, the higher the jitter will be and vice versa (M. Septrio Rafinaldo, Iwan Iskandar, Nazruddin Safaat Harahap, 2023). When testing the five classes, the class that got the highest jitter was in class 11 TKJ 2, this is also due to the long distance and very many users.

Recommendations for schools include: [1] Bandwidth Management, that all existing students can receive the same bandwidth, it is necessary to carry out bandwidth management to be able to share bandwidth evenly for all existing network users. Bandwidth management is a way to manage computer networks so that bandwidth is used optimally and evenly distributed to all Internet users (Ramanda, 2019). This management process can use the PCQ (Per Connection Queue) method because this method is usually used for networks with a large number of users. This method will distribute bandwidth evenly to all users who are connected to a wireless network.
[2] Add Repeaters to classes that have difficulty accessing the internet. Repeater functions as a signal amplifier, this tool is very useful in installing wireless networks in areas with dense buildings or buildings with floors, because in these areas the signal strength is weakened when obstructed by building foundations (Nova et al., 2022). This repeater can be installed in classes that experience a network crisis. In the TKJ department, this can be installed in classes 10 TKJ, 11 TKJ 1, and 11 TKJ 2 because based on the results of the analysis these classes get inadequate internet network quality. [3] Increasing the network frequency from 2.4 GHz to 6 GHz, in 2019, wifi 6 or wifi with a frequency of 6 GHz appeared. The 6 GHz frequency has reliable data transfer capabilities. Wi-Fi 6 can provide high speed and low latency. High network density features bring many benefits to private networks (Made Sutha Yadnya, 2024). The 6 GHz frequency can reduce latency or delay by 75%. This frequency also supports simultaneous data flow with increased throughput,

has a lot of spectrum so that it can create new routes, and has a coverage area four times larger than the 2.4 GHz frequency.

5. Conclusion

Measurement of wireless network QoS at Kefamenanu 1 State Vocational School uses 5 parameters including bandwidth, packet loss, throughput, delay, and jitter. The testing process took samples in the TKJ expertise program using 5 classes. The testing process was carried out for two days during busy and quiet times. The results of the analysis based on the four tests show that the class that gets the worst internet network quality is class 10 TKJ, 11 TKJ 1, and 11 TKJ 2, so it is necessary to improve the quality of the internet network in this class by considering the recommendations that have been given so that network conditions are more optimal.

6. Suggestion

The author also provides some suggestions for future researchers: [1] The author hopes that future research can use the QoS method and the RMA method as well as several parameters in the RMA method to get more accurate results. [2] Future researchers can implement the recommendations given for this school, for example, bandwidth management using the PCQ method at Kefamenanu 1 State Vocational School.

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